On the Tides in the Sound of Harris. By HENRY C. OTTER, Esq., R.N., Captain of H.M.S. Porcupine.* (Plates IV. and V.)

Tides.—The law of the tidal stream in the Sound of Harris is very remarkable, and does not appear to be influenced to any great degree by the wind. It may be generally stated, that in summer, in neap tides, the stream comes from the Atlantic during the whole of the day, and from the Minch during the whole of the night. In winter, the reverse takes place, the Minch stream flows during the day, the Atlantic during the night.

In spring tides, both in summer and winter, the stream comes in from the Atlantic during the greater part of the time the water is rising, but never exceeds 5¼ hours, and flows back into the Atlantic during the greater part of the fall of the tide.

The stream from the Atlantic is therefore denominated the flood stream, that from the Minch the ebb stream.

The rise and fall of the tide was found to be influenced much more by the force and direction of the wind than the moon's parallax. A strong S. or S.W. wind raises the water to equinoctial height, but produces a very poor ebb. The ebbing or falling tide takes 15 to 20 minutes longer than the flood. Where the water is confined by rocks and islands, such as inside of Strome, the Red Rock, &c., the velocity is nearly 5 miles an hour during springs, and not much less during neaps; but in other places it does not exceed 2 to 2½ miles an hour.

Summer.—The ebb stream commences at full and change 1¼ hours before high-water, or 5 A.M., and runs about 6 hours; it then gradually loses upon the time of high-water, so that at mean tides the ebb does not commence until an hour after high-water, and only runs for 4 hours: this lasts for one or two days, when the ebb stream is suddenly found running all night, and continues to do so from one day before the quarter to two days after. At the next mean tides the ebb is found

* Read before the Royal Society, 1st March 1858.

commencing early in the morning, and gradually approaching the time of high-water.

The flood stream commences at full and change 1¼ hour before low-water, and continues to do so for about 3 days; it then rapidly takes an earlier turn, until, at the quarter of the moon, it is found coinciding with the morning low-water, or 6 A.M., and continues to run flood the whole of the day until 8 P.M. The greatest velocity of this stream is in the forenoon, or whilst the tide is rising,—sometimes in the afternoon, about 3 hours after high-water. The stream is very sluggish; and, if blowing hard from the S. or S.W., a faint ebb stream will be felt for an hour, or an hour and a-half; after which the flood resumes its place, and continues rather longer than it would otherwise have done but for this.

Winter.—The ebb stream commences at full and change the same as in the summer, about 1¼ hours before high-water, or 5 A.M.; it then gradually gains upon the time of high-water, until the quarter of the moon, when the ebb commences 3¼ hours before high-water, or 8·15 A.M., and runs until 7 P.M. The greatest velocity of this stream was found to be about 3 hours after high-water, or 3 P.M.

The flood stream, after running all night in neap tides, has only a short duration in the forenoon of mean tides; but, as an approximate rule, the flood commences in the day-time about the time of the moon's transit.

The above remarks apply to the eastern side of the Sound.

In the middle and on the western side of Berneray, the law is modified, and in some places altogether different.

Narrows of Berneray (*Summer*).—At full and change the flood stream commences half an hour before low-water by the shore, and continues to run in that direction 5 hours—the greatest velocity being 2½ to 3 miles an hour.

The ebb stream turns an hour before high-water by the shore, and runs with the same velocity.

In neap tides there is from 8 to 9 hours' flood in the day-time, and not more than 2 to 4 hours' ebb.

In winter, in neap tides, there is from 2 to 4 hours' flood during the day.

Hermetray Group, as before mentioned, at all times re-

ceives the flood stream from the Minch, which turns three-quarters of an hour later than high-water by the shore.

Groay Group.—In spring tides, the flood stream, or the stream from the Atlantic, only runs for $2\frac{1}{4}$ hours after high-water, and then turns to the north; the greatest velocity is $1\frac{1}{2}$ miles an hour. Further to the northward the flood stream runs longer.

The diagram, which is appended, will give a close approximation to the turn and duration of the stream in the day-time during the summer and winter months; but at the equinoctial, when the change is about taking place, the table can only be depended on at full and change.

Explanation of Diagram. (Plates IV. and V.)

To find the time of high-water, look out the moon's A.M. meridian passage, for the day required, at the top of either table; and at the side, where the two lines intersect the black curve, the time of high-water will be found.

To find when the ebb and flood stream begins and ends, look out the moon's A.M. meridian passage at the top, as before, in the summer or winter table, according to the time of year, and the white space will show the duration of ebb, the shaded space the duration of flood.

Notes to Captain Otter's Paper on the Tides in the Sound of Harris. By James Stark, M.D. F.R.S.E.

An interesting subject of inquiry is the probable cause of the flow of the current through the Sound of Harris. As the tidal wave in its progress from the south flows up both sides of the Western Isles, as far as the Sound of Harris, at the same time, so that at both the eastern and western extremity of the Sound the time of high-water is attained at the same hour, it is evident that the peculiar flow of the current through the Sound cannot be due to the tidal wave. The circumstance of the stream flowing from the Atlantic into the Minch all day during the summer months, but during the winter flowing all day from the Minch into the Atlantic, suggests the idea that,

during summer, the level of the Atlantic must be *higher* during the day than during the night; while, *during winter*, the level of the Atlantic must be *lower* during the day than it is during the night; in fact, that this peculiarity in the tidal current is somehow connected with the length of the day. The influence of the sun on the tides is known to all in the phenomena of what are termed "spring" tides, which occur when the sun and moon are in conjunction, or in opposition; that is to say, at the periods of new and full moon. But the phenomena described by Captain Otter are evidently to be ascribed to a different cause.

If we suppose that the sun exerts a strong attractive power over a large body of water like the Atlantic, which is undeniable, then we should expect that attraction to be greatest, and its effect in raising the level of the water most marked, when the sun was more immediately over that body of water. Taking it for granted that the sun's power of attraction is just in proportion to the length of time when it shines on any particular body of water, then the great mass of the Northern Atlantic in the same parallel of latitude as Harris, would have a higher level during the day in the summer months than it would have during the night when the sun's attractive power was removed. As the Minch is, to a certain extent, a confined sea, the current from the Atlantic would, therefore, flow into it all day; but when the level of the North Atlantic fell during the night, in consequence of the sun's attractive power being removed, the current would flow from the Minch into the Atlantic.

During winter, again, the sun's rays being most powerful over the Southern Atlantic, as it is now to the south of the equator, the waters of the North Atlantic would be attracted southwards during the day, so that its level would be lower than that of the confined waters of the Minch. Consequently, during the winter months, we should expect that the stream would flow through the Sound of Harris from the Minch into the Atlantic all the day. When the sun's attractive power, however, over the Southern Atlantic was removed during the night, the waters would fall to their level and allow the North Atlantic to regain its level; so that during the night the cur-

rent during the winter season would flow through the Sound of Harris from the Atlantic.

On the supposition that this explanation is the true one, it appears to me that it throws light on a phenomenon which has been long remarked, but never satisfactorily accounted for,—viz., that during one period of the year the highest tides occur when the moon is *above* the horizon, but during the other half of the year when the moon is *below* the horizon. Now, if the moon be above the horizon during the summer when the level of the Atlantic is higher than usual from the greater attractive power of the sun, the day tide will be higher than the corresponding night tide. But if the moon be above the horizon during the day, when the Atlantic level is *below* its mean, as during winter, then the day tide will be lower than the corresponding night tide.

It would be interesting to ascertain, by actual measurements, whether there is any difference in the level of the waters in the Atlantic and Minch, and to what extent that difference exists during day and night, and during summer and winter; and I expect that this will be ascertained during the present year through the zeal of Captain Otter and Lieutenant Thomas, who are both engaged in the survey of the western coast.

Description of New Protozoa. By T. Strethill Wright, M.D., Fellow of the Royal College of Physicians, Edinburgh.*

Explanation of Plates.

Plate VI.

Fig. 1. *Lagotia viridis*, showing rotatory organ from lateral aspect.

2. Front view of do.

3. Tip of one of the lobes of rotatory organ—*a* large ciliary band—*b* striæ bearing cilia.

4. Young animal of *L. viridis*.

5. *Vagincola ampulla* (Müller).

6. *Vagincola valvata*, animal extended, and (7.) contracted—*a* valve raised—*b* do. closed.

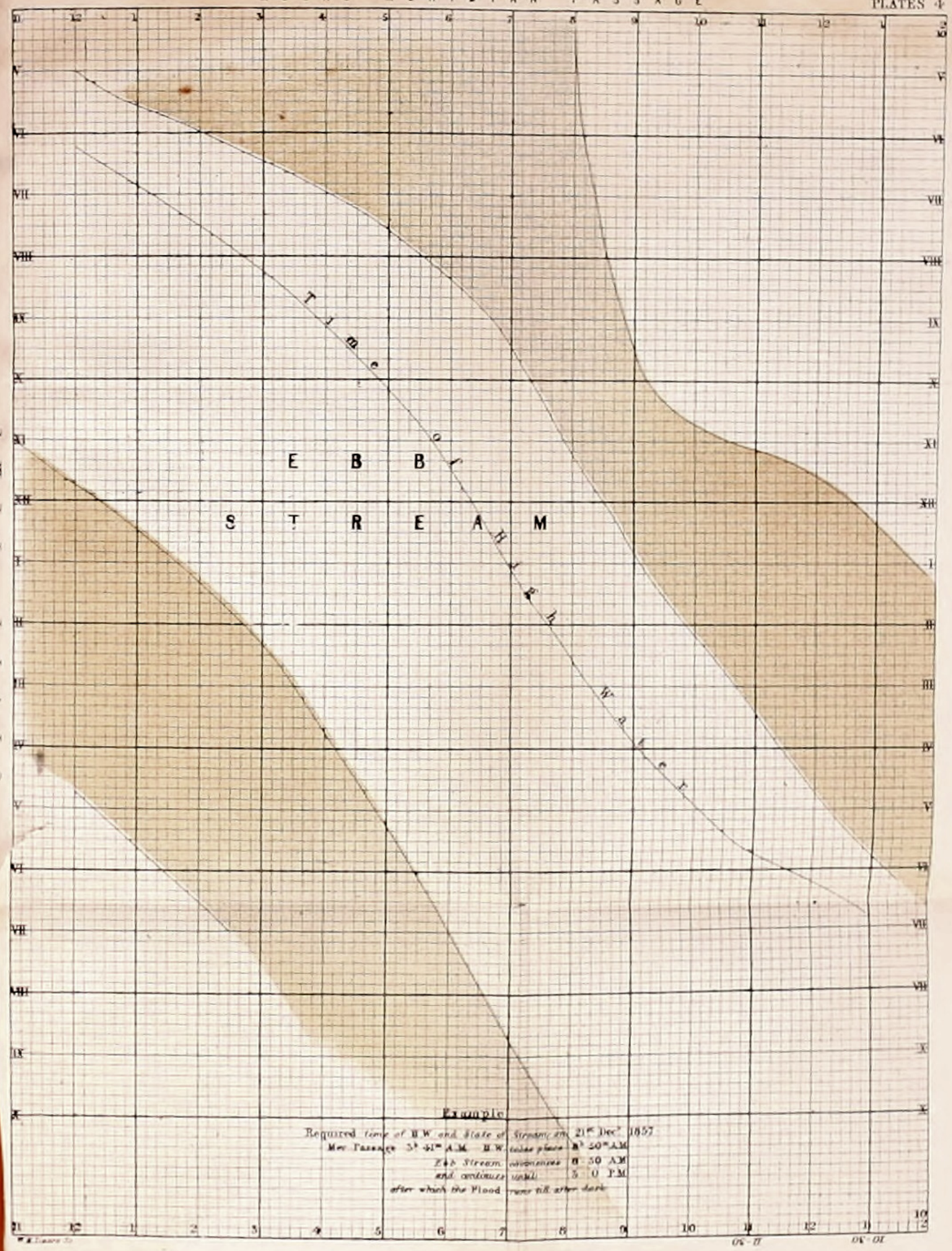
8. Diagram of upper part of tube of *V. valvata*—*a* tube—*b* sarcode lining do.—*c* valve closed—*d* sarcode coating tube on outside.

* Communicated to the Royal Physical Society of Edinburgh on the 25th April 1857.

WINTER SEASON

MOON'S MERIDIAN PASSAGE

PLATES 4 and 5



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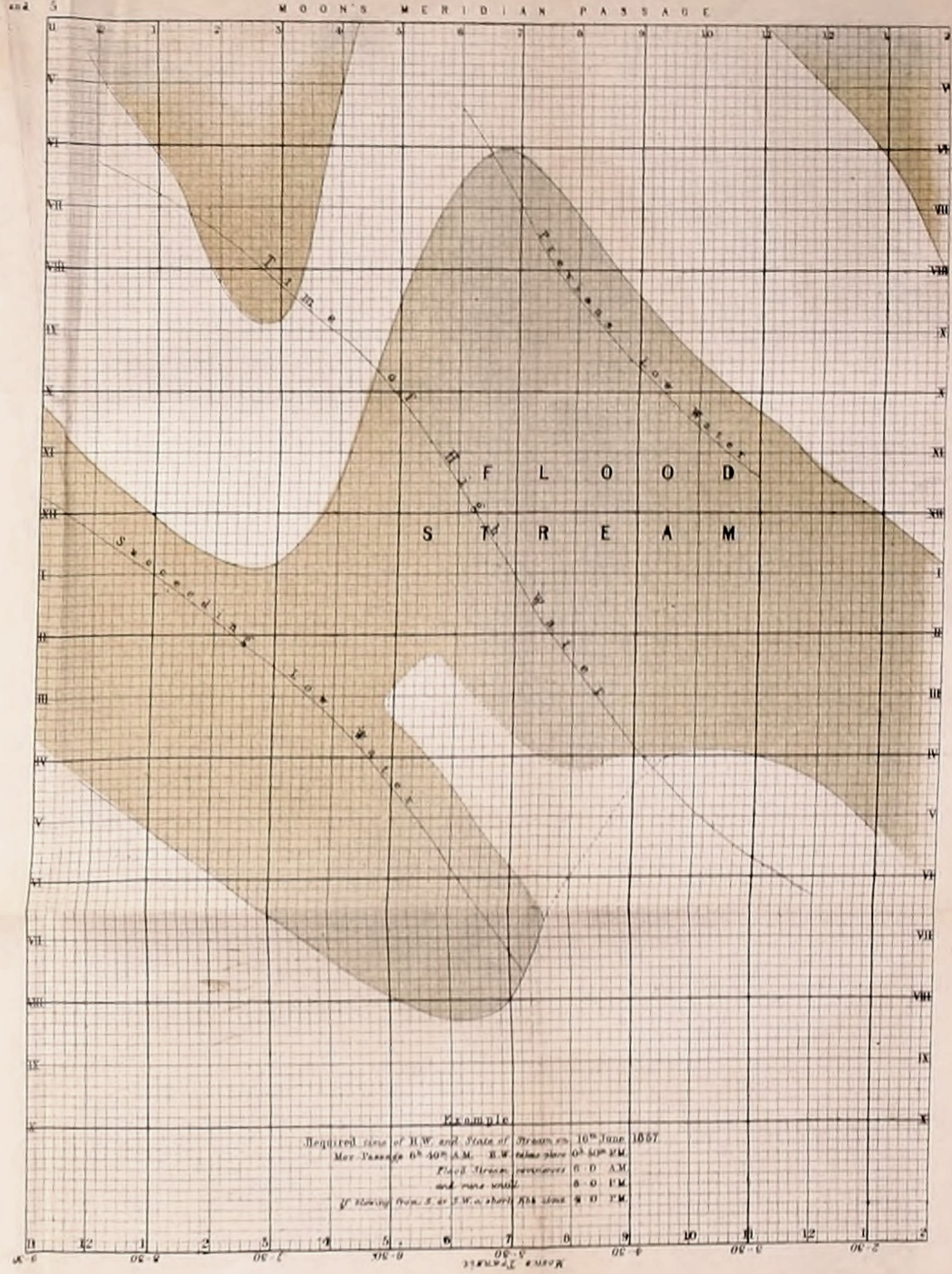
SUMMER SEASON

MOON'S MERIDIAN PASSAGE



WINTER SEASON

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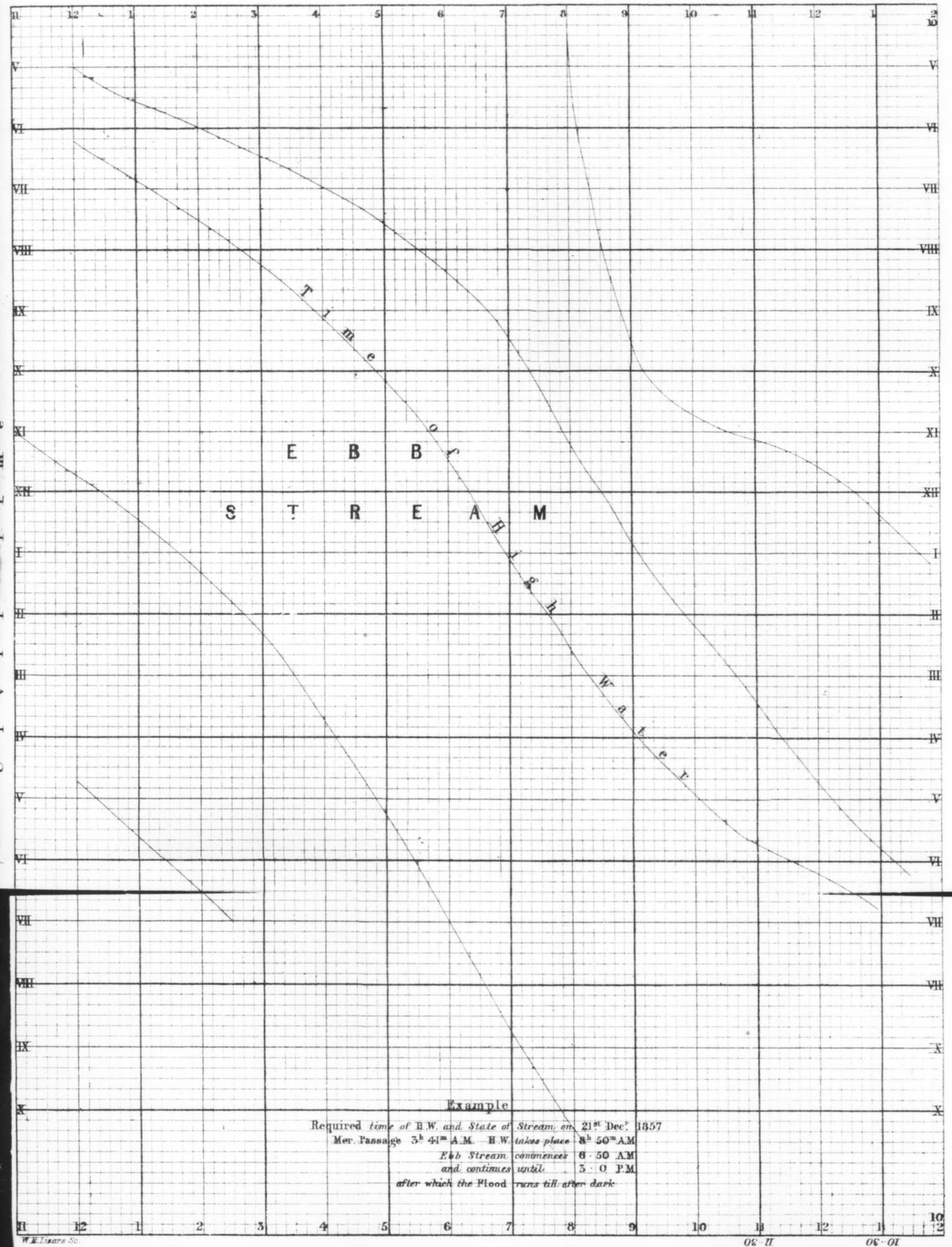


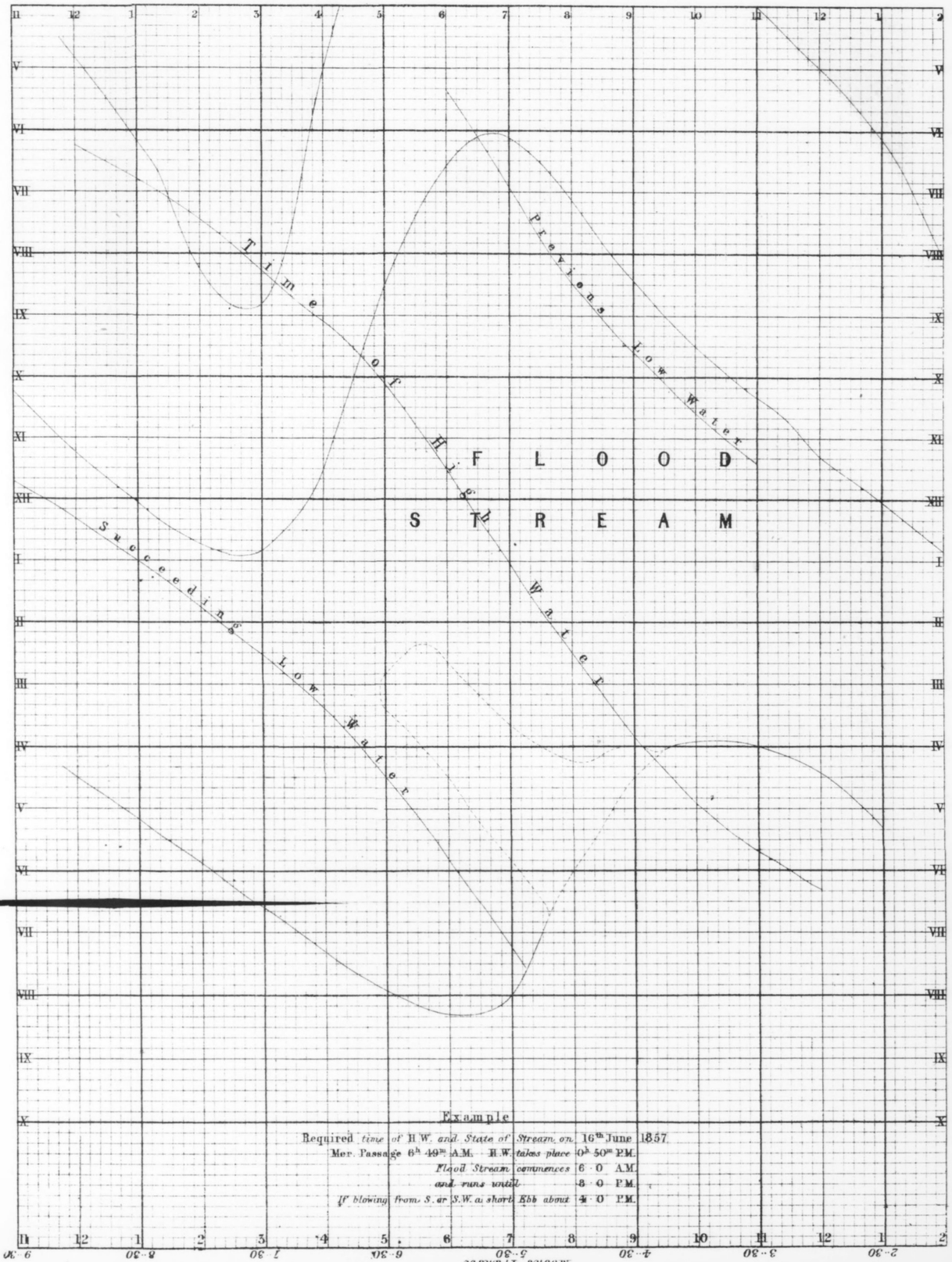
Example

Required *time of* H.W. *and State of Stream, on* 21st Dec.r 1857

Mer. Passage 3h 41m A.M.	H.W. *takes place*	8h 50m A.M.
	Ebb Stream commences	6 · 50 A.M.
	and continues until	3 · 0 P.M.
	after which the Flood runs till after dark	

SUMMER SEASON

MOON'S MERIDIAN PASSAGE



Example

Required *time of* H.W. *and State of Stream, on* 16th June 1857

Mer. Passage 6h 49m A.M.	H.W. *takes place*	0h 50m P.M.
	Flood Stream commences	6 · 0 A.M.
	and runs until	8 · 0 P.M.
	If blowing from S. or S.W. a short Ebb about	4 · 0 P.M.

CIVIL TIME

W.E.Evans Sc.

MOON'S TRANSIT